Palomar Testbed Interferometer - Update

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for the PTI Collaboration

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Members of the PTI Collaboration

Name	Affiliation	Primary PTI Interests
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R. Bambery	JPL	
A. F. Boden	Caltech	Spectroscopic Binaries Astrometry
M. M. Colavita	JPL	Astrometry
M. J. Creech-Eakman	JPL/Caltech	Mira Variable Stars Young Stellar Objects Mid-IR Instruments and Detector Technology
P. J. Dumont	JPL	Astrometry
C. D. Koresko	Caltech	RS CVn Stars
M. Kuchner	Caltech	Cepheid Variables
S. R. Kulkarni	Caltech	Science Program Coordination
B. Lane	Caltech/JPL	Main Sequence Stars Instrumentation
P. Lawson	JPL	Astrometry Instrumentation
R. Linfield	Caltech	Atmospheric Studies
M. Shao	JPL	
M. Swain	JPL	Differential Phase
R.R. Thompson	JPL/University of Wyoming	Evolved Stars Stellar Angular Diameters
G. T. van Belle	JPL	Evolved Stars Stellar Angular Diameters
D. Van Buren	Caltech	
G. Vasisht	JPL	
J. K. Wallace	JPL	Instrumentation
F. P. Wilkin	Caltech/IPAC	Young Stellar Objects Astrometry

Overview

- Introduction to PTI
- The 1999 Observing Season
- Instrument Improvements
- Astrometry
- Phase Referencing
- Software Developments
- Future Plans

Instrument Description

- NASA funded, tech dev. for Keck and other interferometers
- 2-way system, 110 m max baseline
- 40 cm collecting apertures
- Active broadband fringe tracking at K (2-2.4 μm) or H (1.5-1.8 μm)
- Spectrometer resolution of R = 25 – 50
- Angle tracking at R + I (0.7 – 1.0 μm)
- Dual-star capability for narrow-angle astrometry

More detail:
ApJ 510, 505 (1999)

Observing Modes

- Single Star Mode
  - One interferometer, one baseline, visibility measurements
  - Binary stars, stellar apparent diameters
- Bright Dual-Star Mode
  - Two interferometers, independent fringe tracking
  - Astrometry of similar-brightness visual binaries (61 Cygni)
- Faint (or Phase Referenced) Dual-Star Mode
  - Two interferometers, tracking info from brighter star fed to other fringe tracker
  - Astrometry with faint reference

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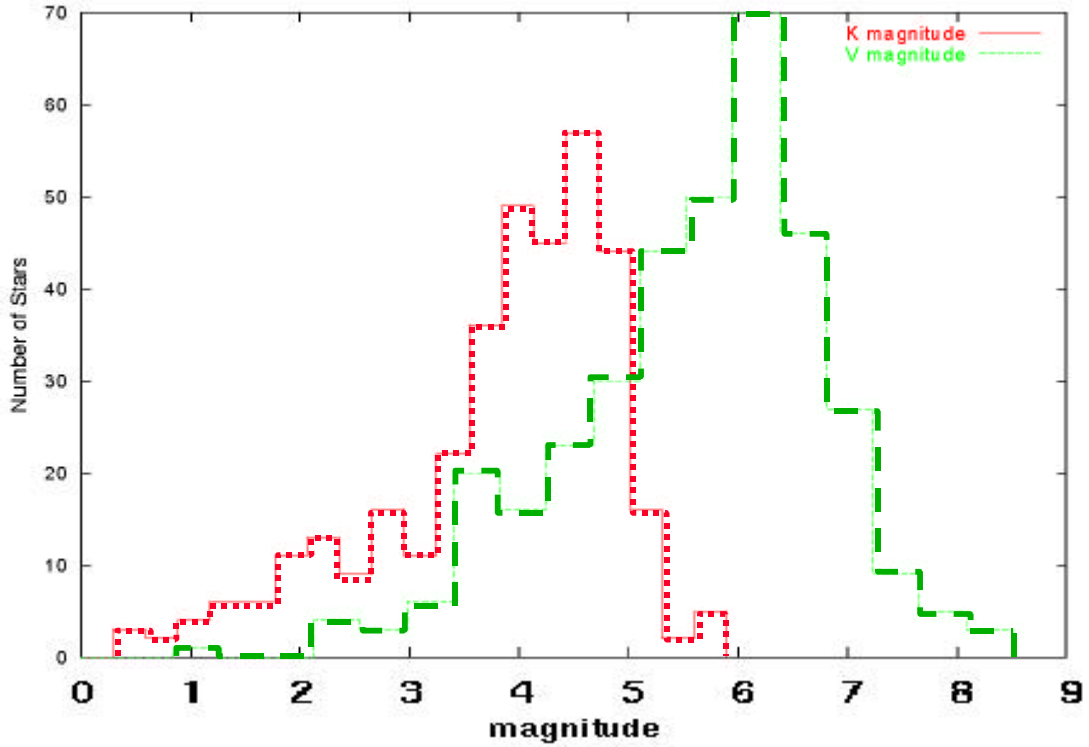
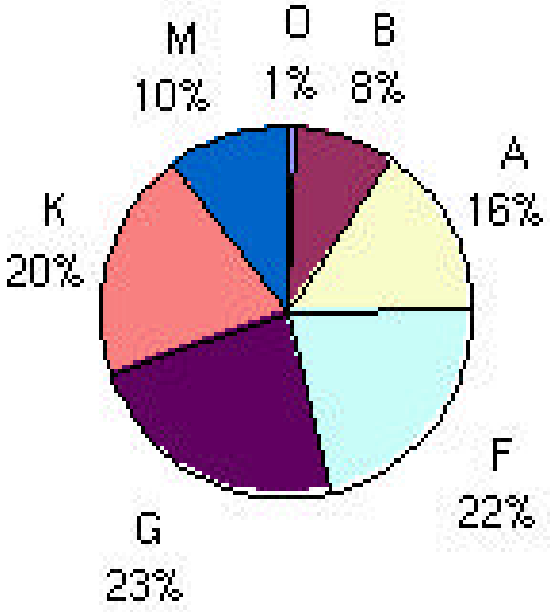
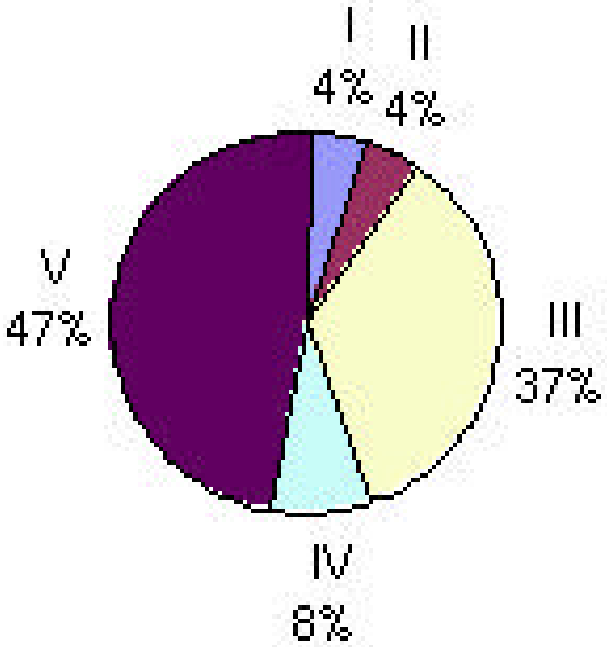
Observing Stats 1999

- Up 227 of 291 possible nights
  - 184 single star
  - 28 bright dual-star
  - 15 phase-reference testing
- 9788 scans on 574 separate targets
  - (1 scan = 130 sec of fringe tracking data + calibrations)
- Highest-throughput night: 122 scans
- Efficiency (fraction time tracking fringe + calibrations): 30%

Observing Stats 1999





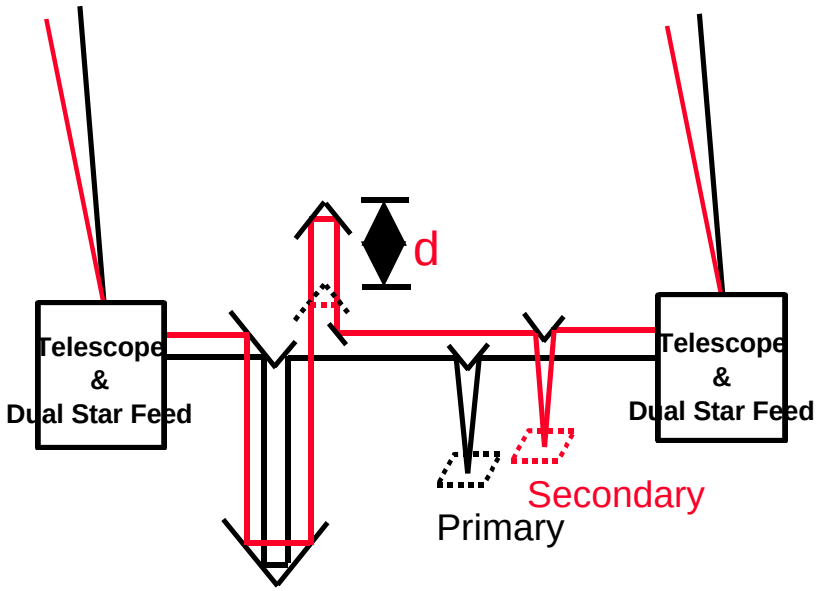


New in 1999 Season

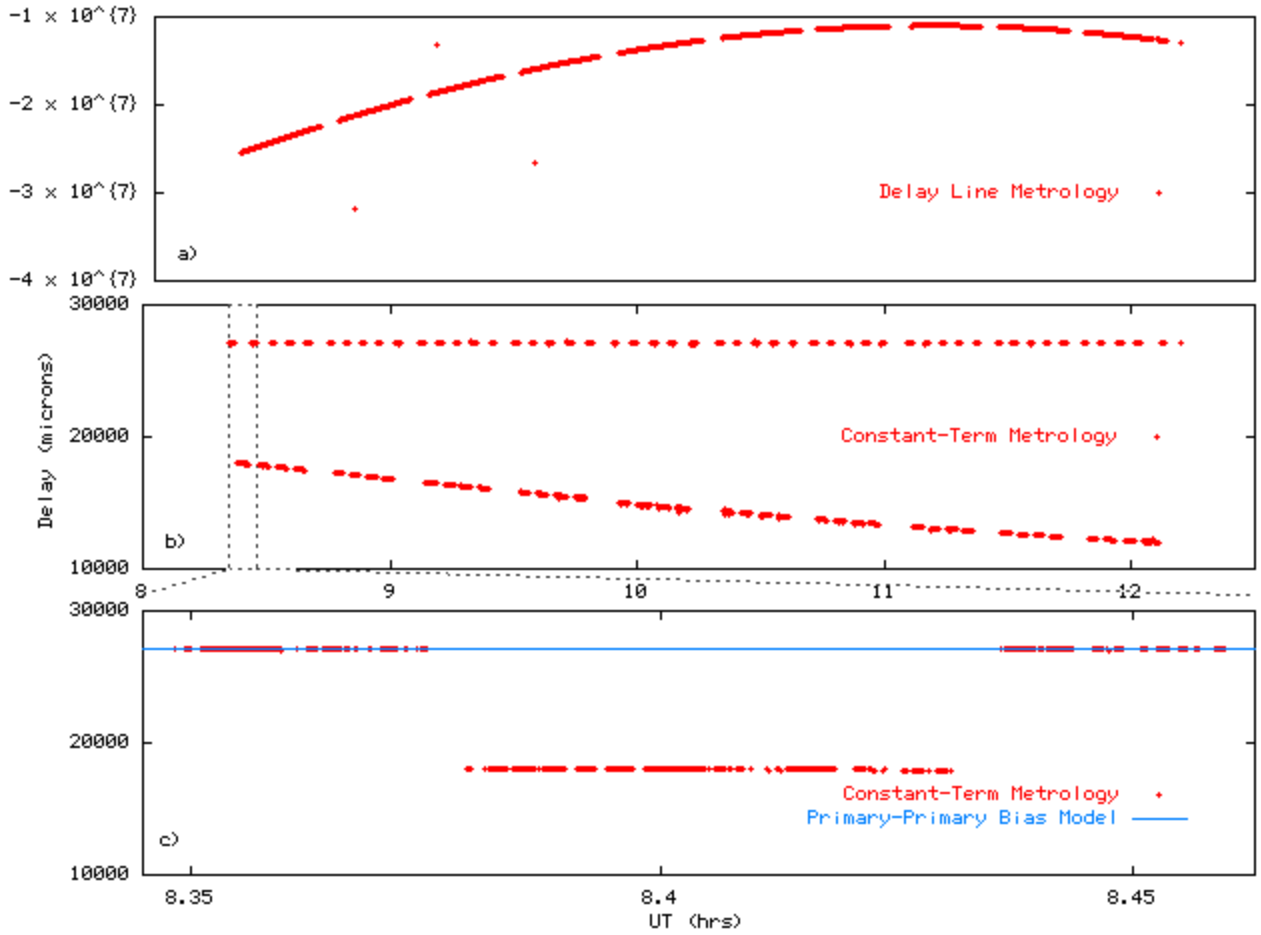
- Routine H-band capability
- Selectable coherent integration times
  - » 10, 20 ms for fringe tracking
  - » 50, 100, 250 ms for phase referenced
- Phase referencing with pathlength feedforward
- Narrow-angle baseline monitoring
- Automated pipeline reduction, archiving, reporting
- New observation planning tools

Narrow-angle astrometry with PTI

- With a long-baseline interferometer, accuracies <100 uas are possible with differential measurements over small fields
- Approach
  - Dual-star feed to separate out target star from astrometric reference
  - Dual beam combiners to allow simultaneous measurements
    - » One beam combiner tracks target star
    - » Second beam combiner switches between stars
  - Laser metrology to control systematic errors



Narrow-Angle Astrometry



- We measure $\Delta d = B \cdot s + a$
- Baseline (B) is determined from wide-angle astrometry

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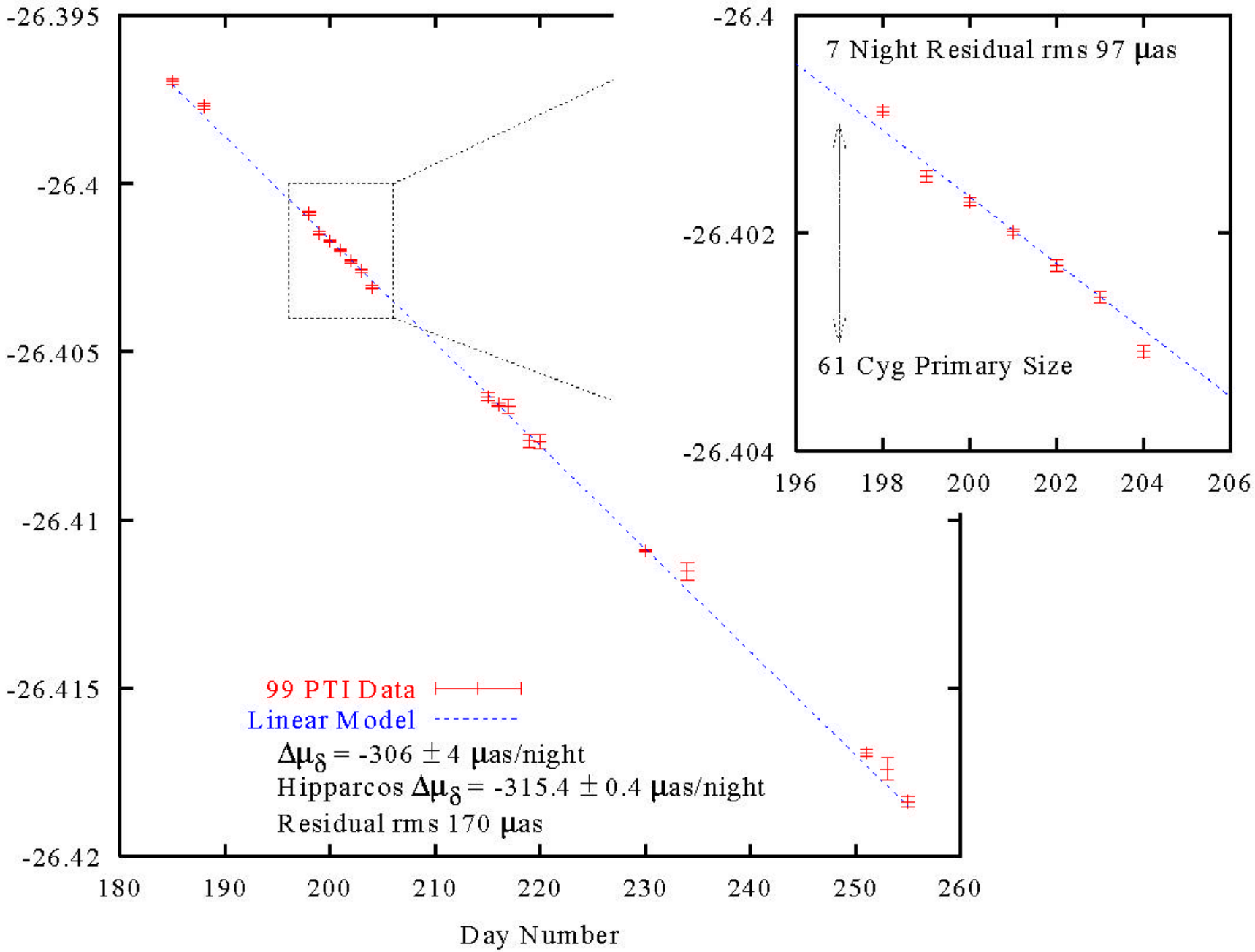
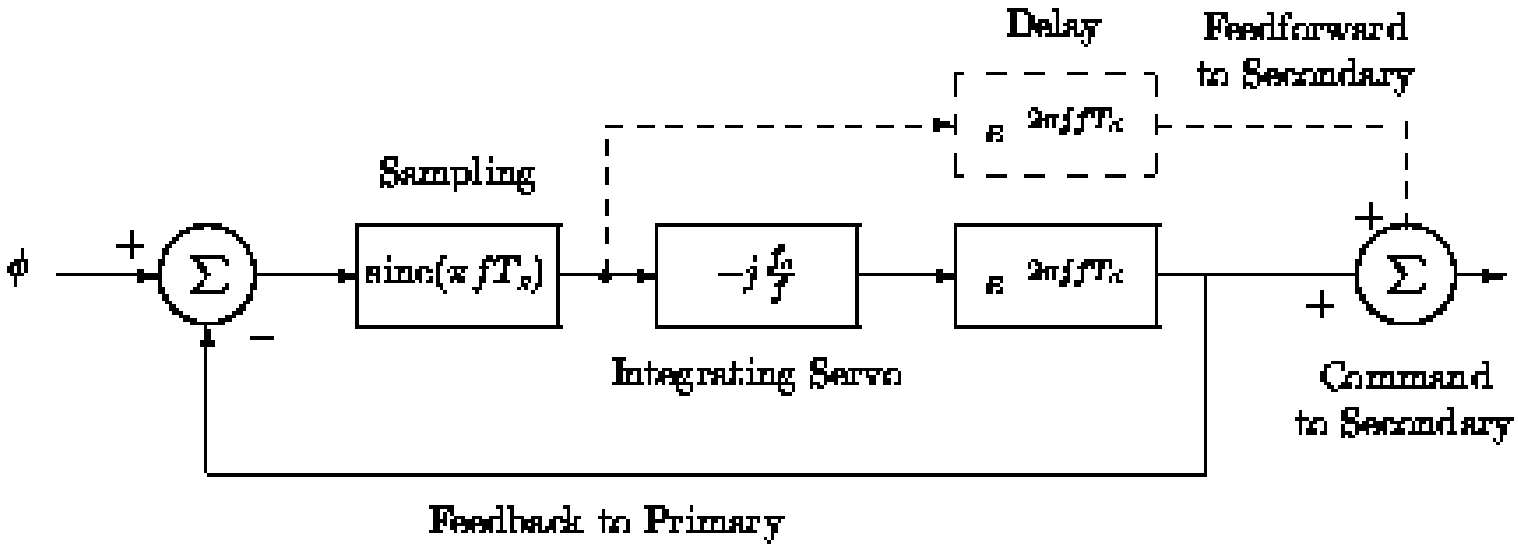
61 Cyg Astrometry



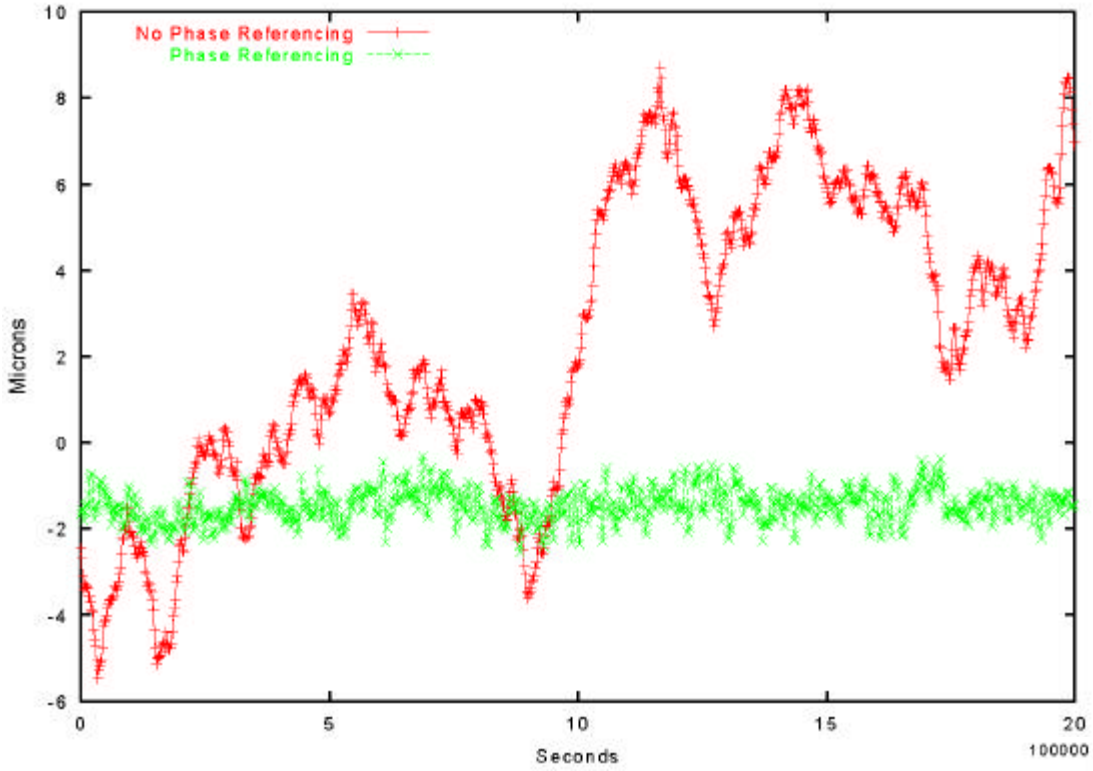
Phase Referencing with PTI

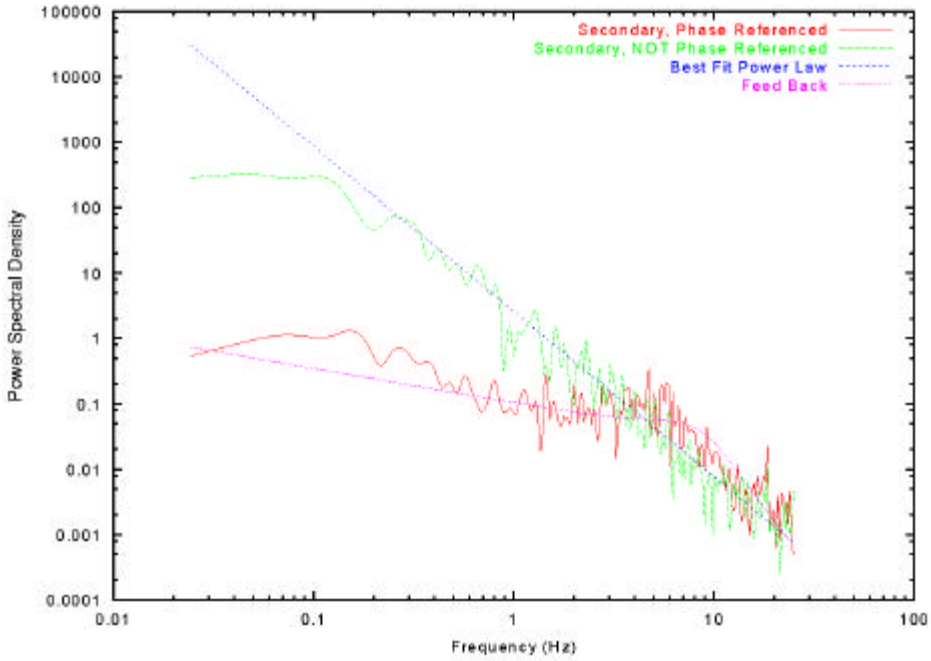
- Analogous to adaptive optics on a large telescope
- Approach
  - Fringe track on a bright star within the isoplanatic patch of the target star
  - Use as a probe of the atmospheric effects on the target star
  - Correct using optical delay lines by
    - » Feedback same signal to both stars' delay lines
    - » or... Feedforward signal to secondary star's delay line
- Advantage
  - Allows longer integration times that would ordinarily be possible
    - » Improved sensitivity

The Fringe Tracking Control Loop

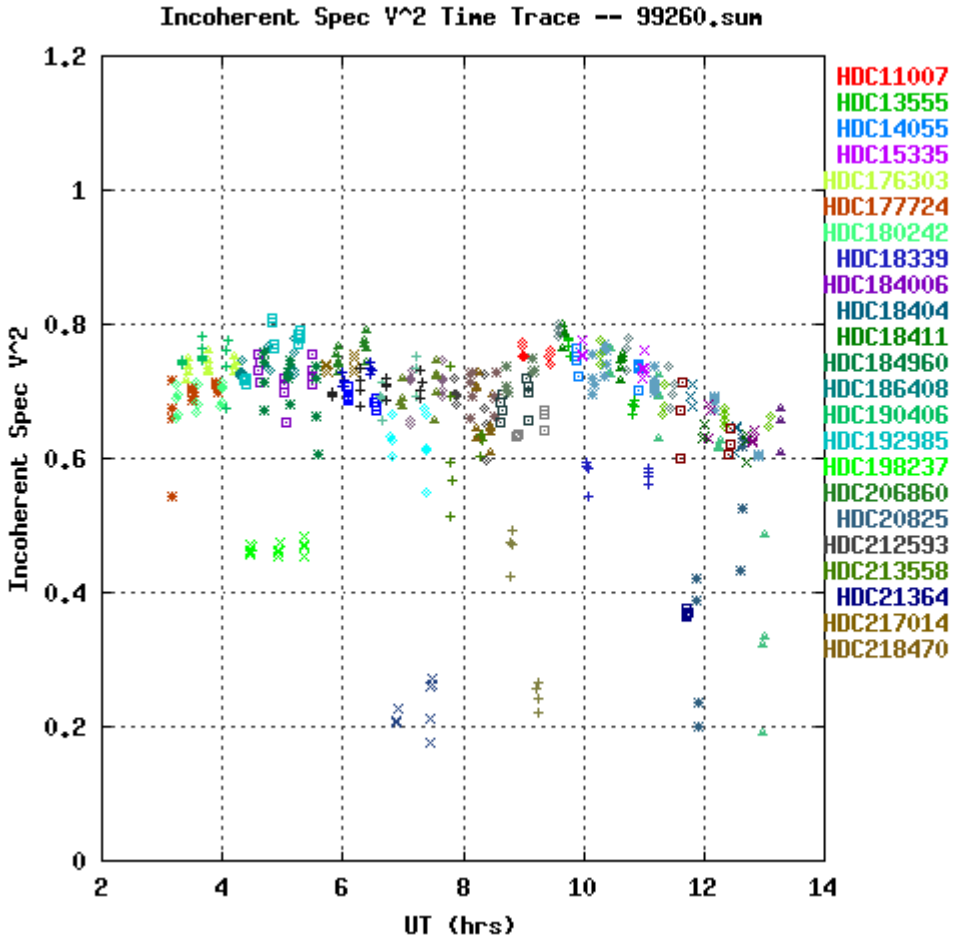


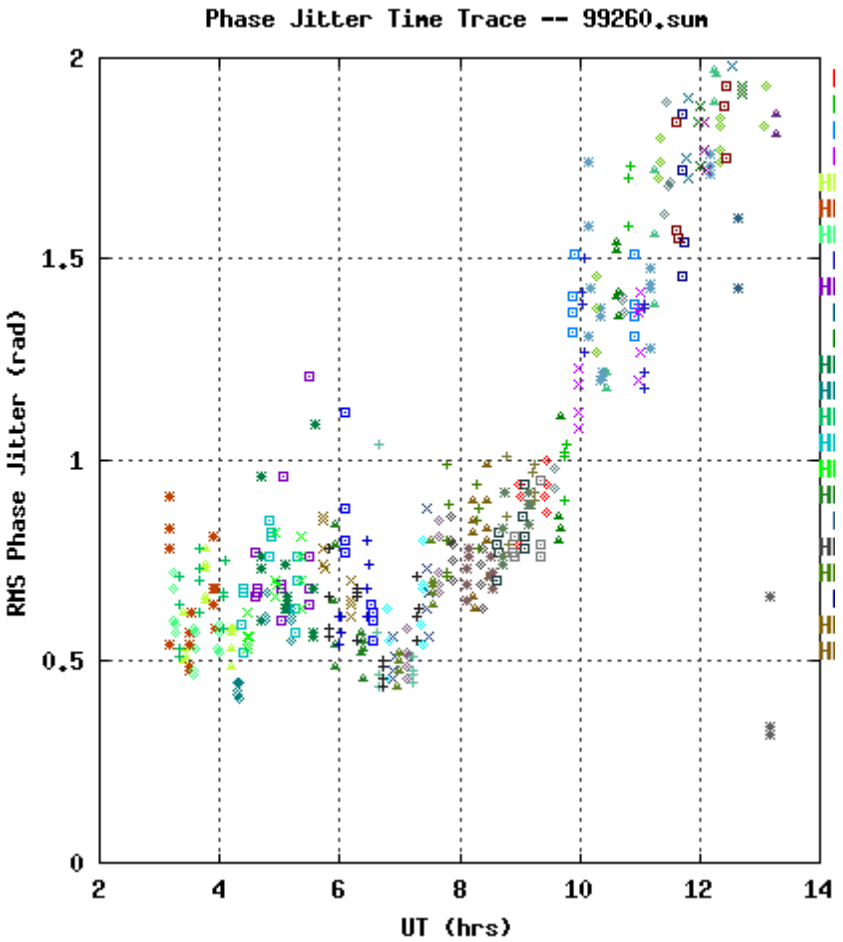
Phase Referencing with PTI



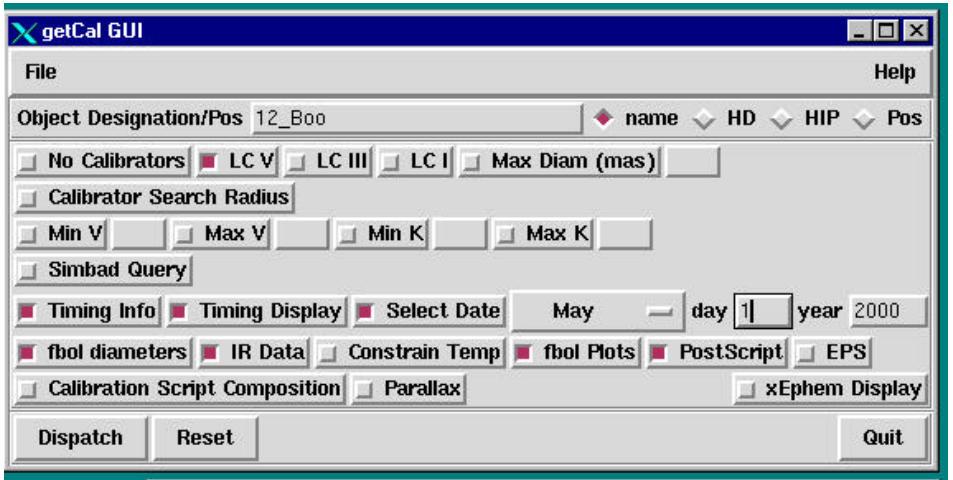


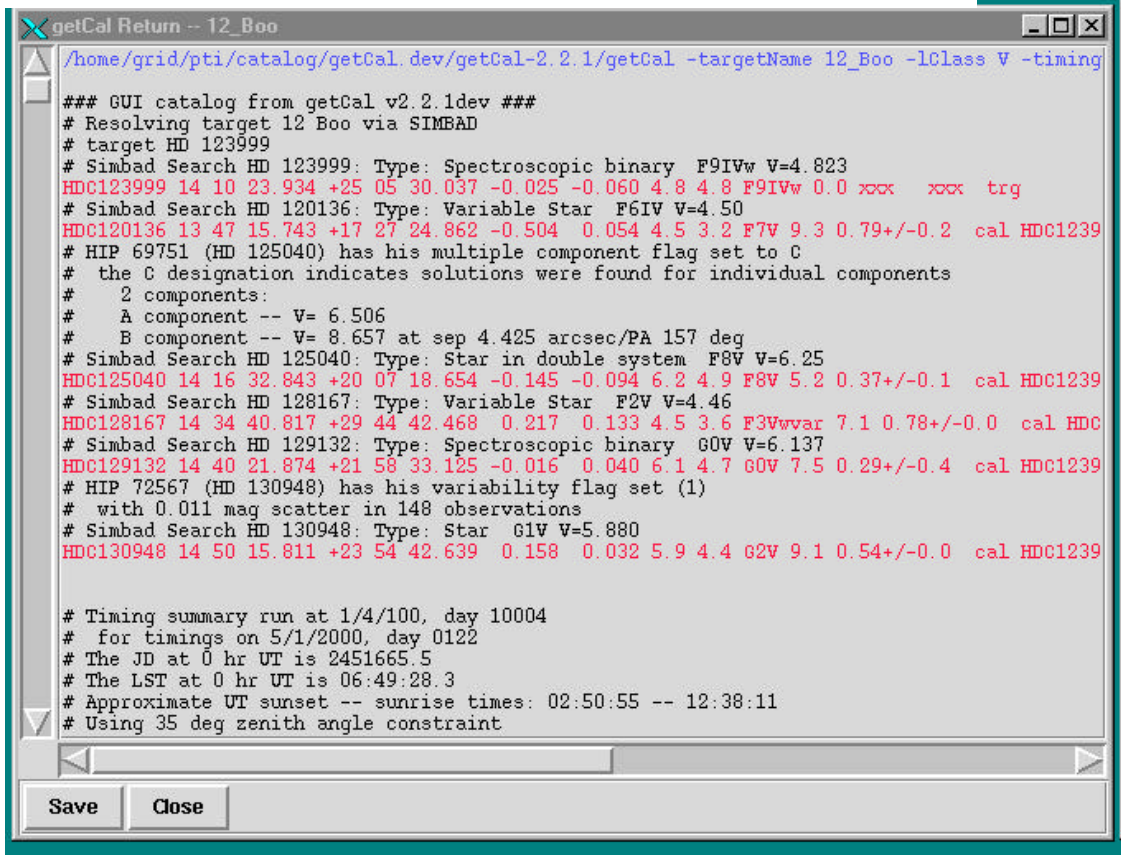
Visibility and Seeing Data (25 sec points)

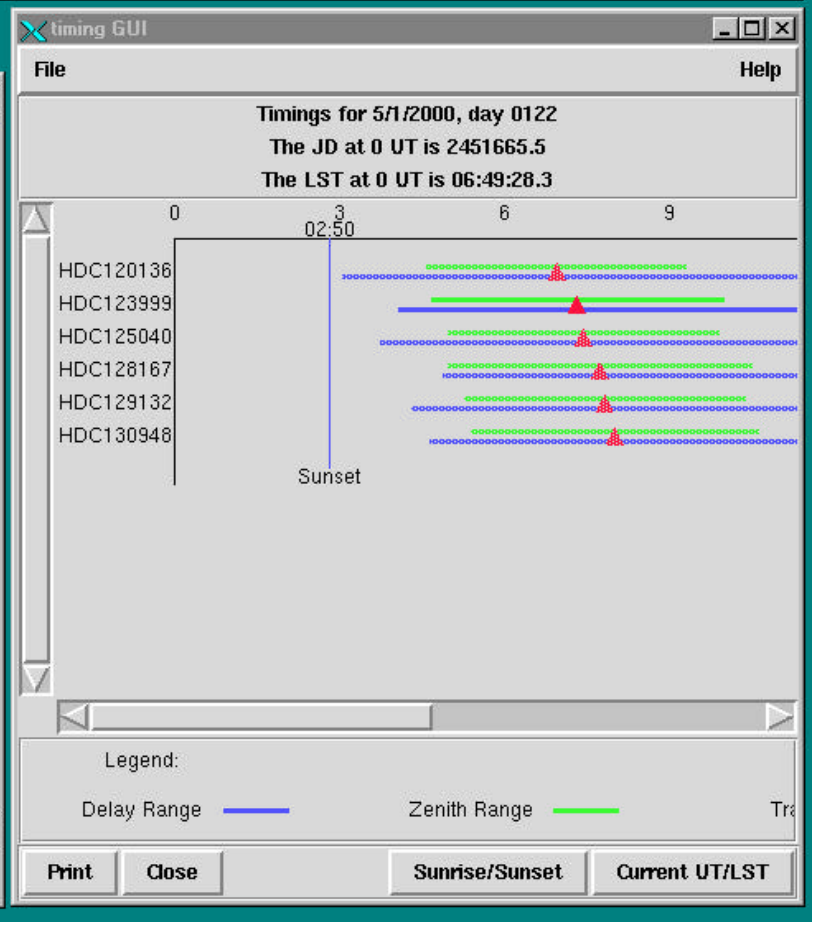




- Automated Calibrator Selection
  - Physical Parameter Estimation (Teff, diameter)
  - Database query (Hipparcos, Simbad)
- Timing/Delay Range Calculations
- Real-Time Target Availability GUI

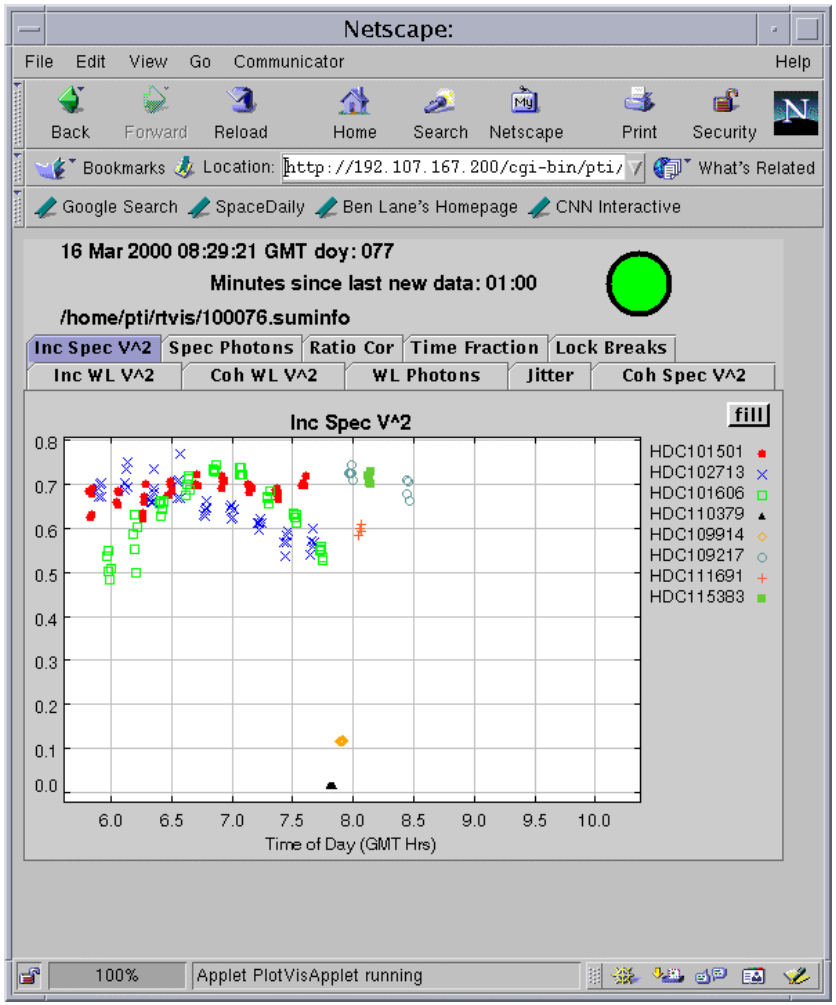






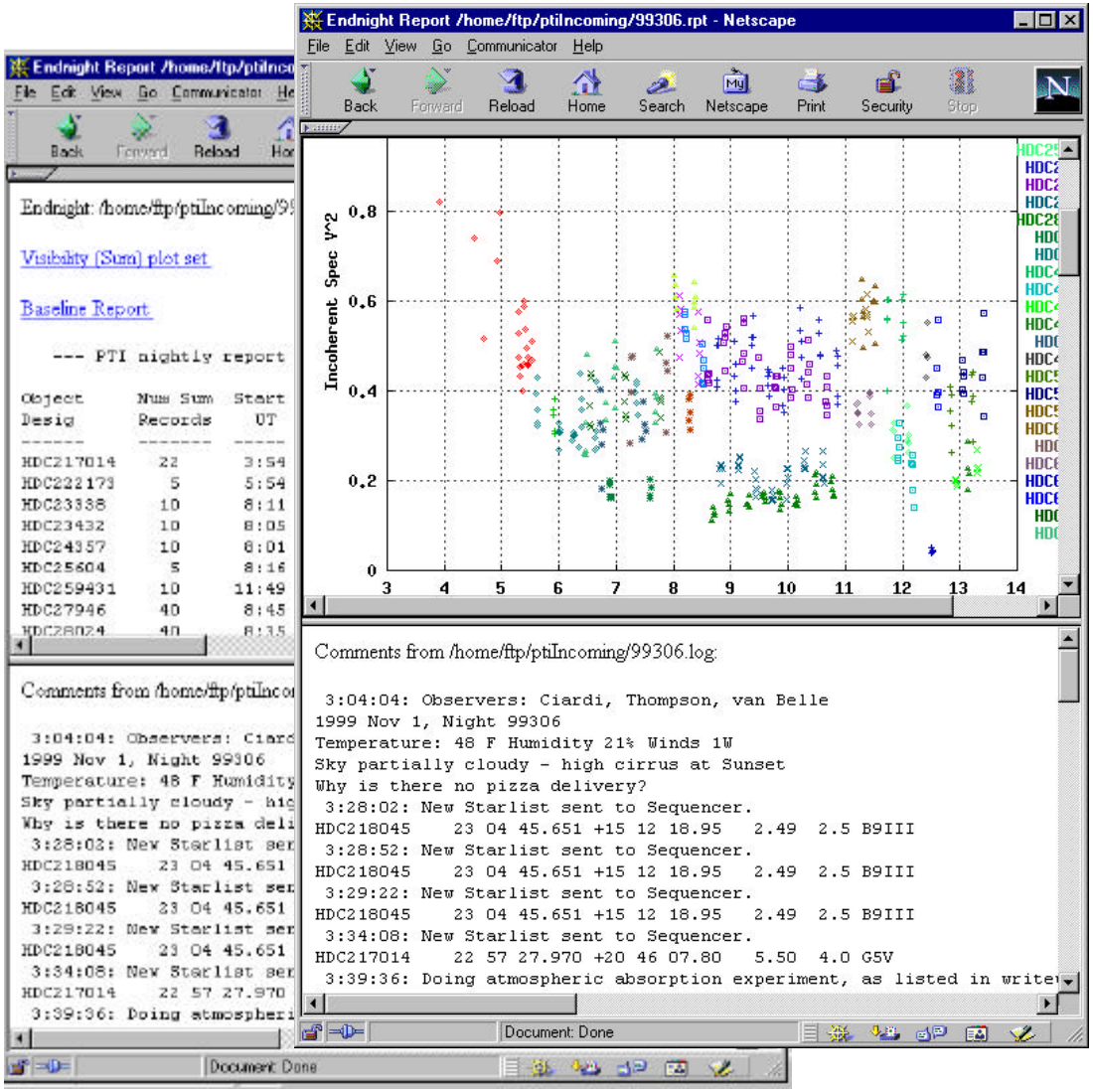
Quick-Look Data Processing

- Real-time data processing
  - Visibility
  - Fringe Jitter
  - Intensities, Ratio
- WWW/Java interface
  - Access from anywhere



Automated Level-1 reductions

- Scripts automate end-of-night reductions
  - Level -1 reductions
    - » Calibrated visibilities
    - » 25 sec visibility points
  - Baseline model
  - Email report to collaborators
  - Web access to nightly summary, log
  - CD burns of level-0 data



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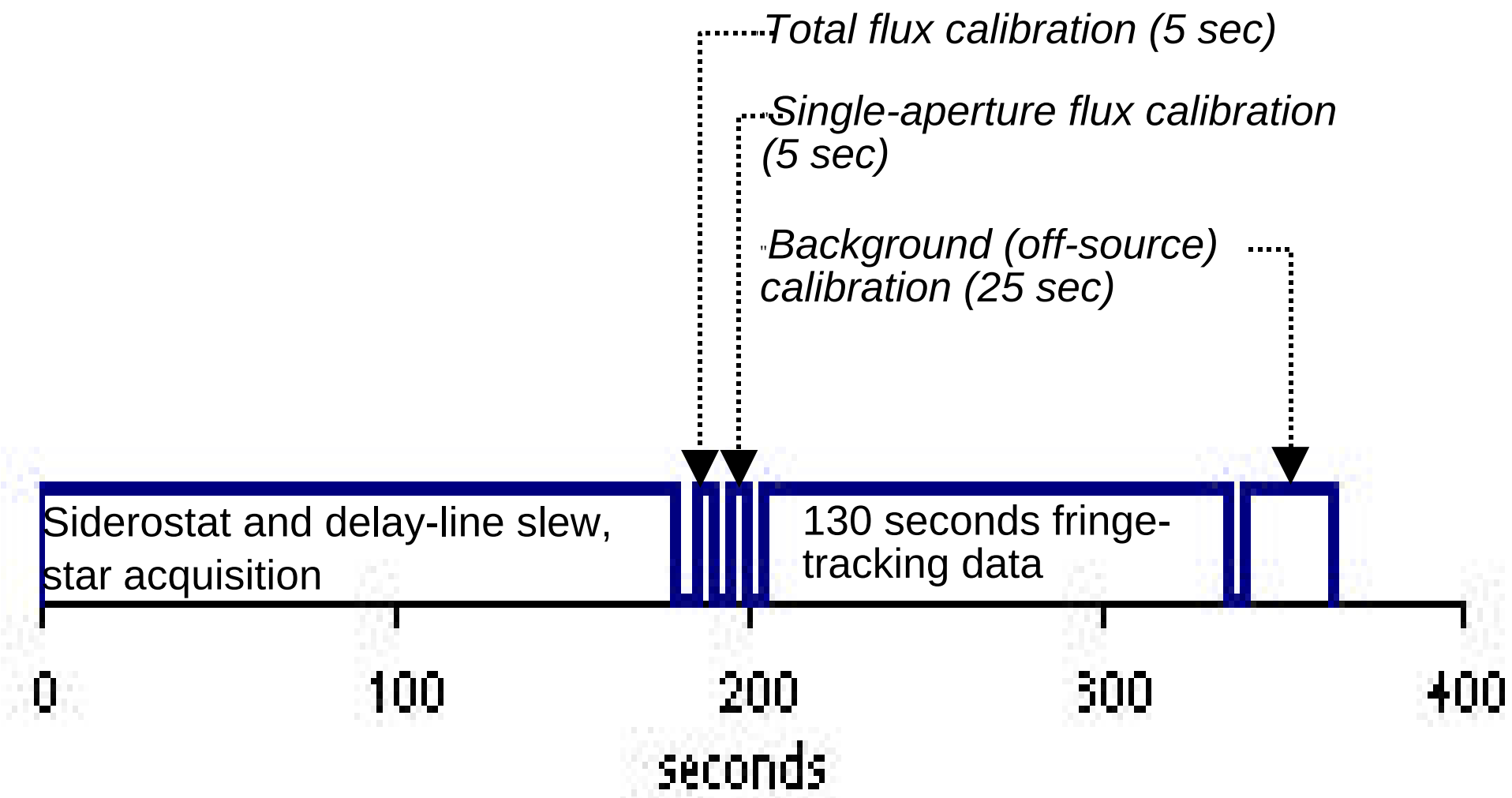
New for 2000 Season

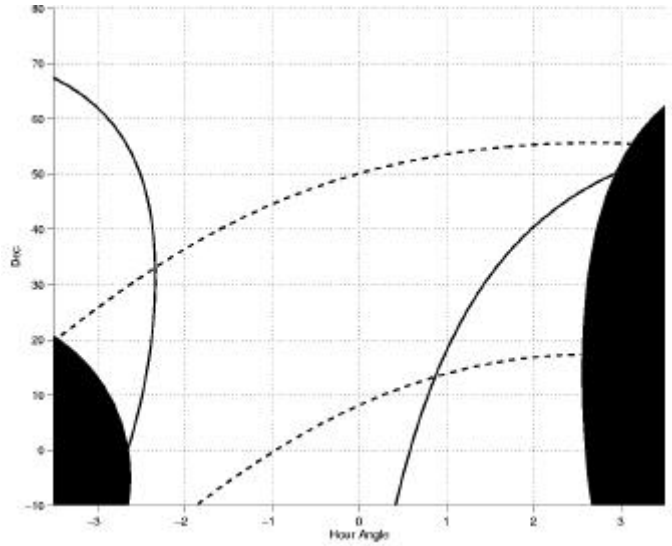
- Low-Background Dewar
- HAWAII Detector
  - » Improved read noise
  - » Improved spectrometer resolution (R~100)
  - » Improved Tracking Limit (mK > 6)
- Operational North-West Baseline
  - » Extended Sky Coverage
  - » 2D astrometry
- Improved Siderostat Pointing
  - » Increase Observing Efficiency

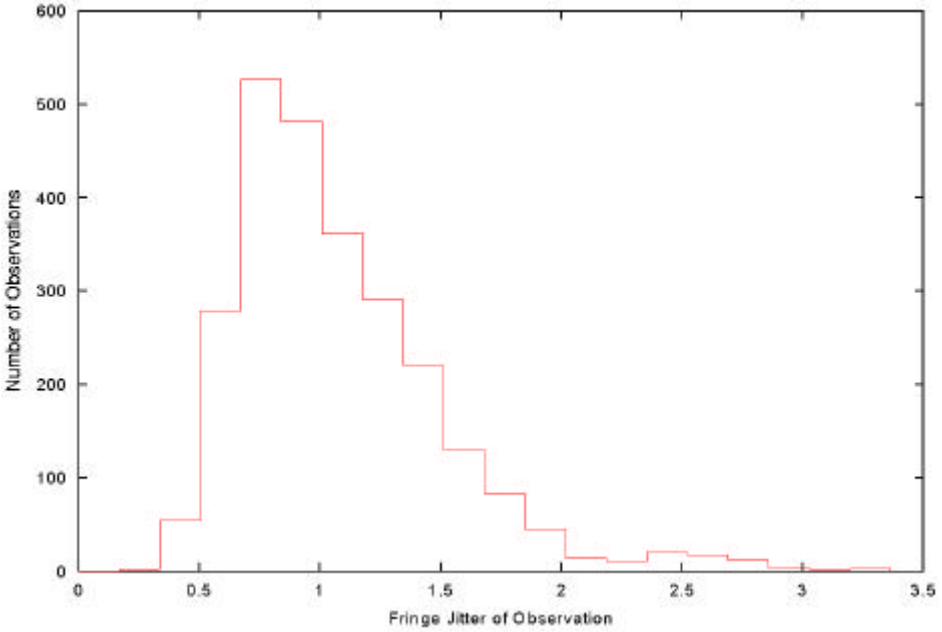
Backup

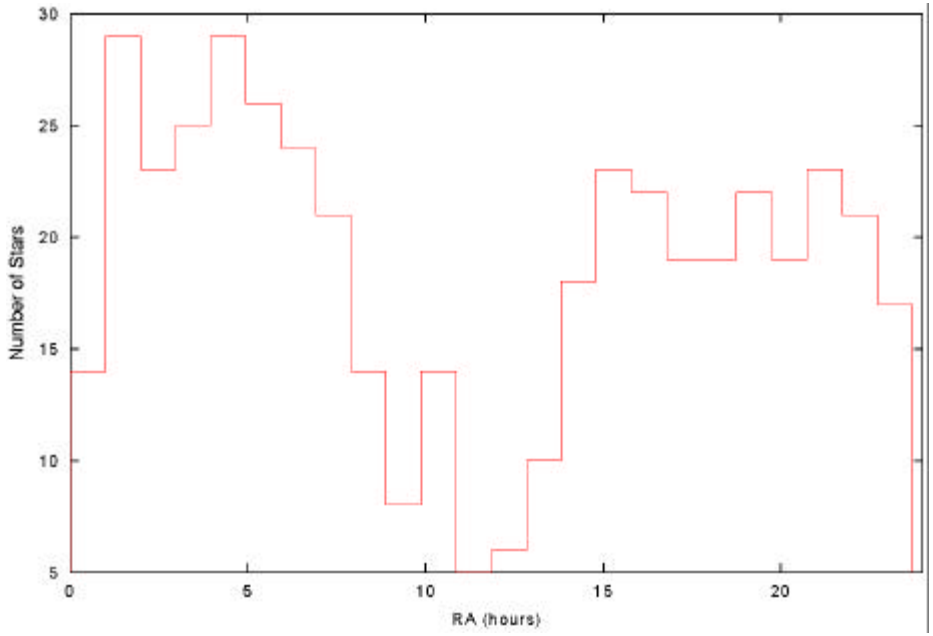
A “Scan”

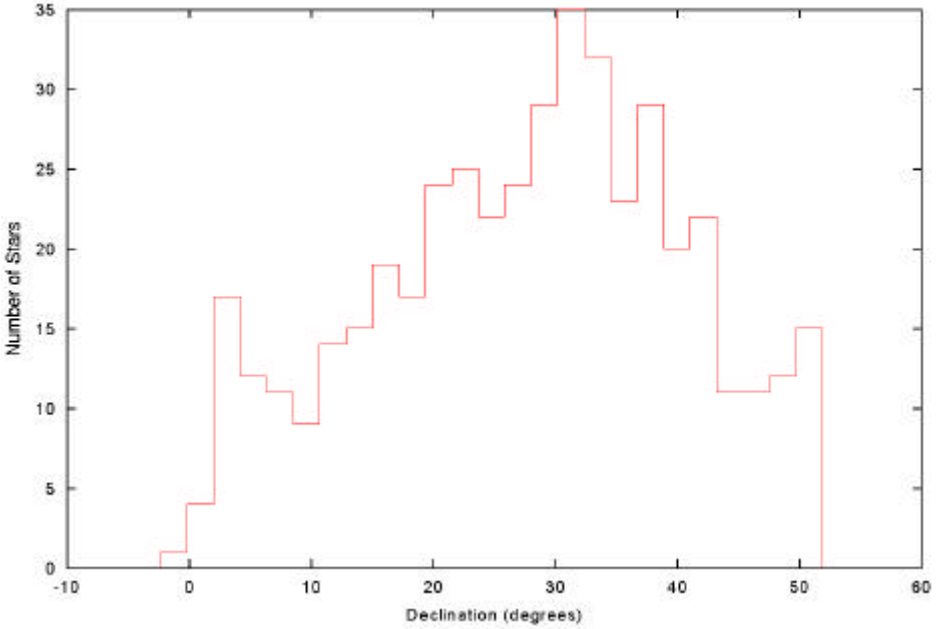

Total flux calibration (5 sec)
Single-aperture flux calibration (5 sec)
Background (off-source) calibration (25 sec)
Siderostat and delay-line slew, star acquisition
130 seconds fringe-tracking data
0
100
200
300
400
seconds

More Observing Stats

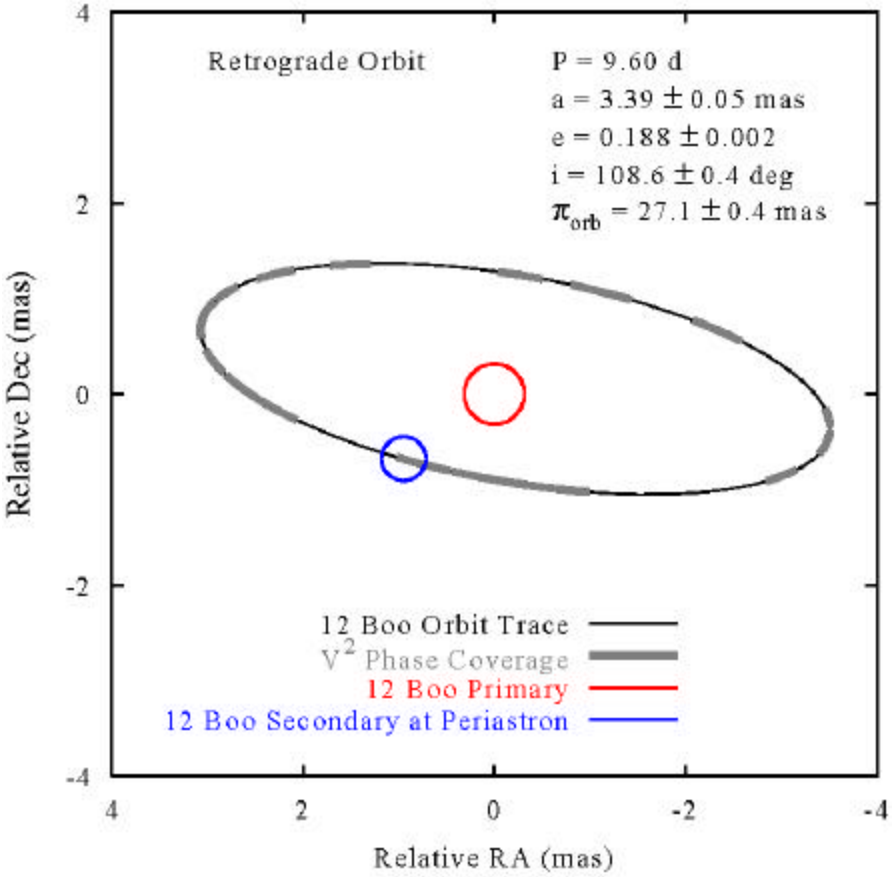


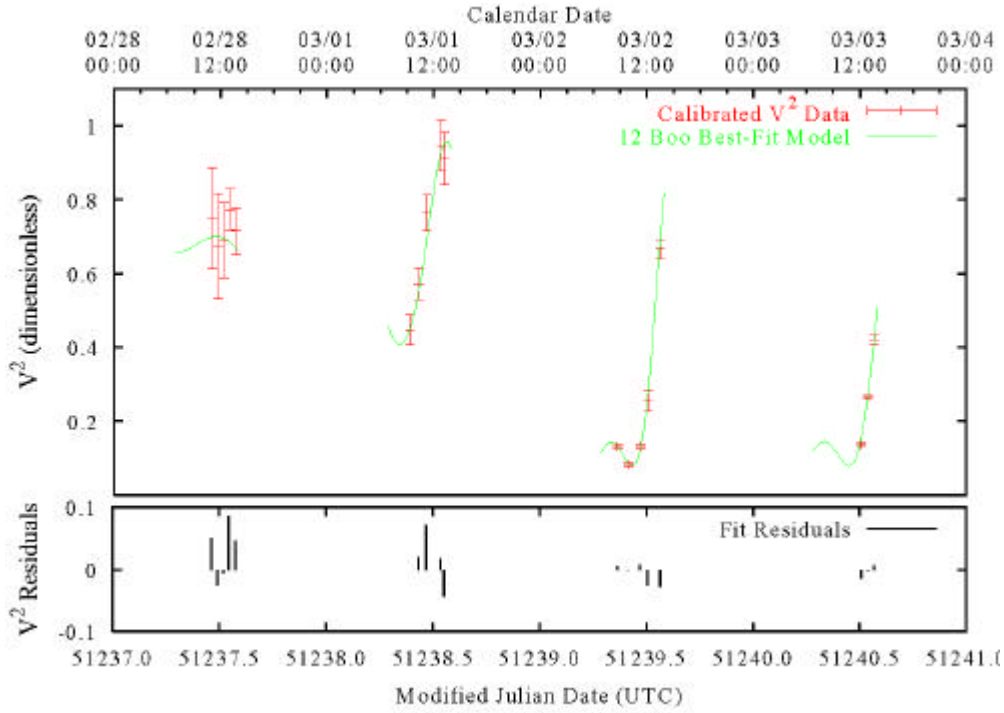


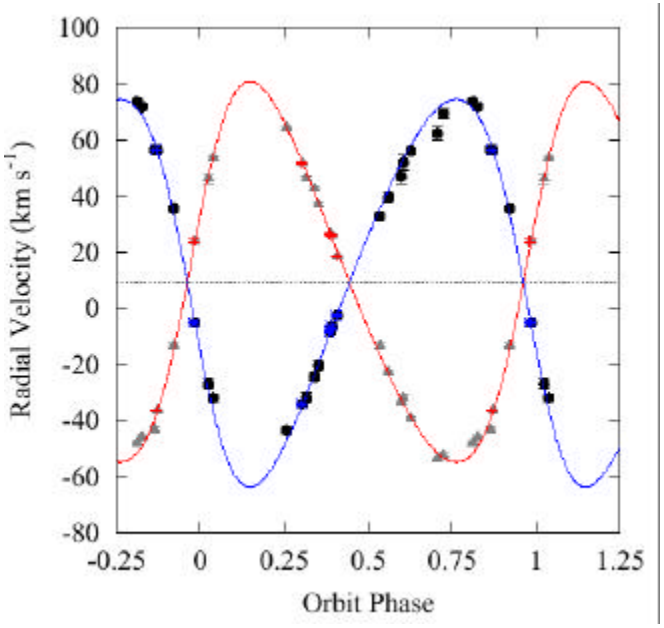




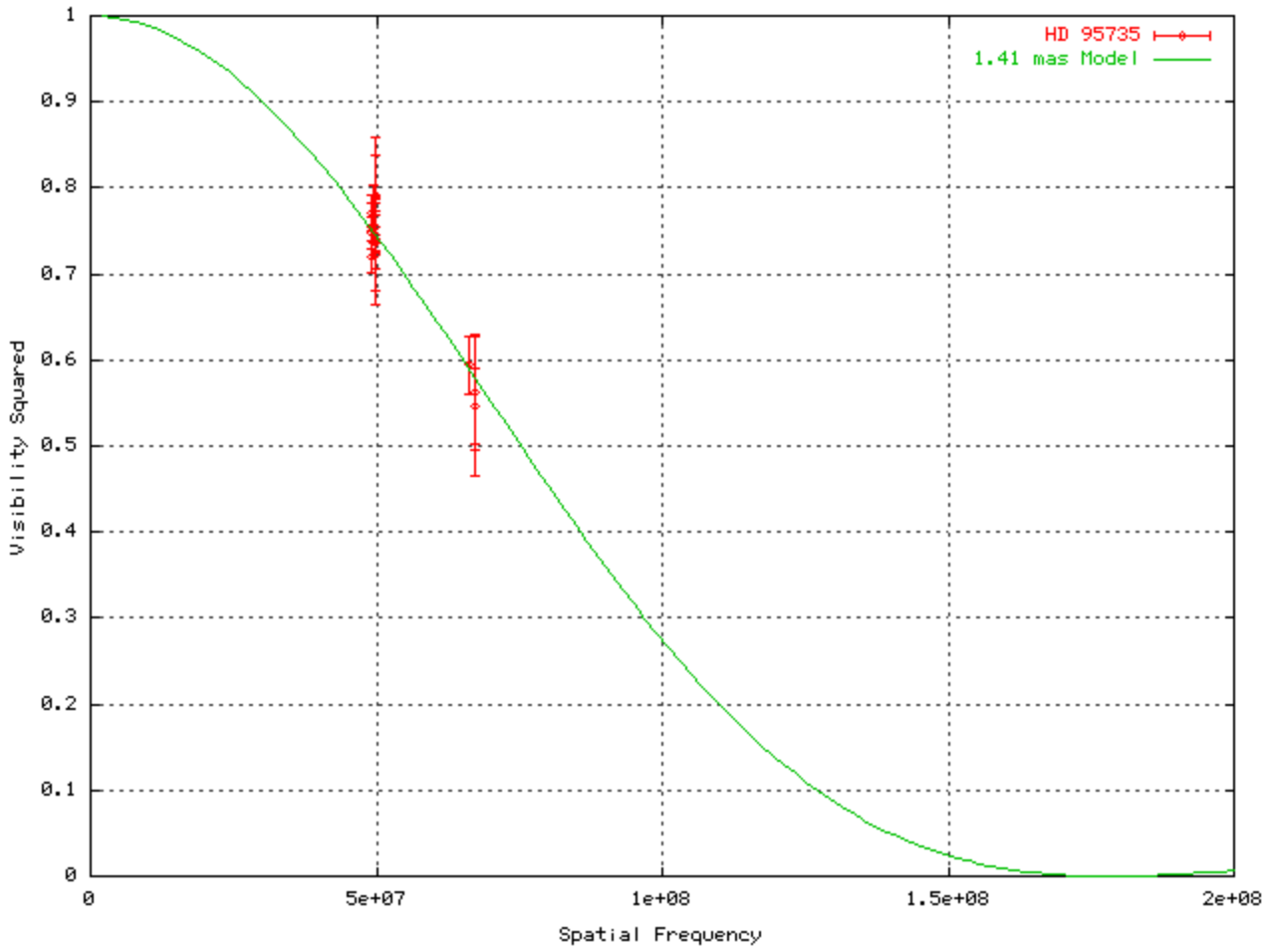
12 Boo Analysis



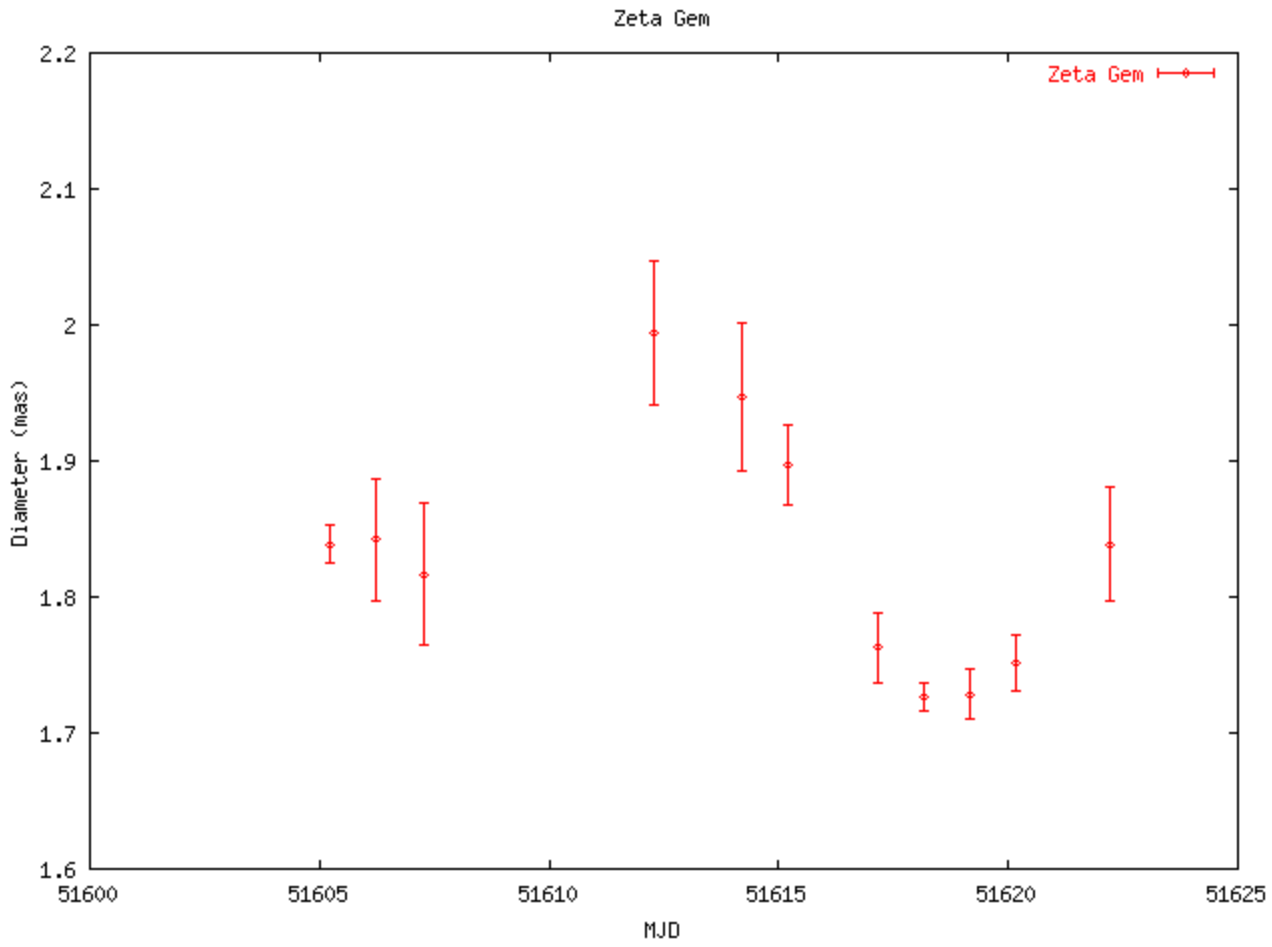




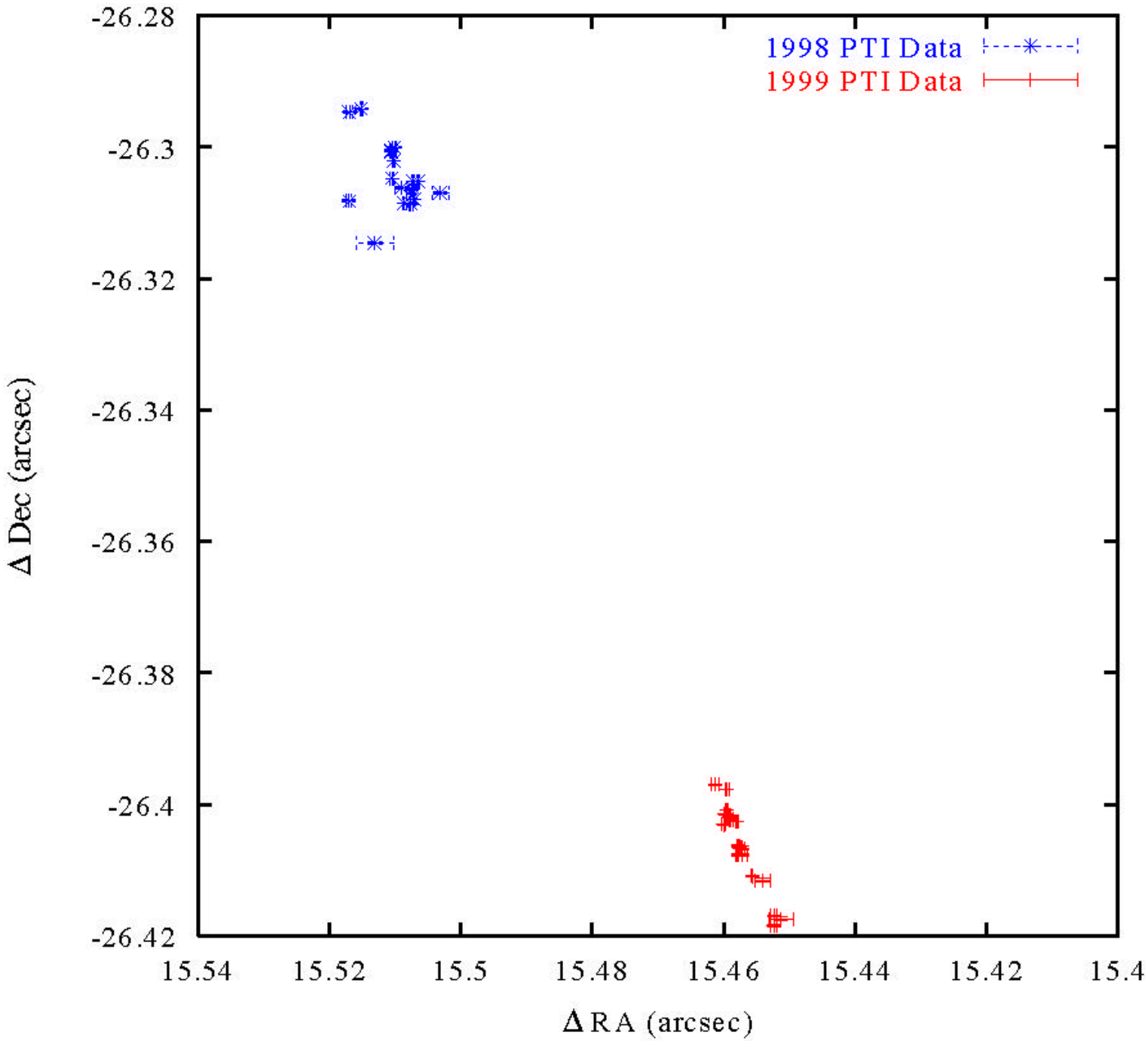
Measuring Diameters



Z Gem


Zeta Gem
Zeta Gem
Diameter (mas)
2.2
2.1
2
1.9
1.8
1.7
1.6
51600
51605
51610
51615
51620
51625
MJD

61 Cyg Astrometry



61 Cyg Astrometry